Supplemental Document

Optics EXPRESS

Toward high laser power beam manipulation with nanophotonic materials: evaluating thin film damage performance: supplement

T. U. TUMKUR,[1] R. SOKHOYAN,[2] M. P. SU,[2] A. CEBALLOS-SANCHEZ,[1] G. KAFAIE SHIRMANESH,[2] Y. KIM,[2] H. A. ATWATER,[2] E. FEIGENBAUM,[1,4] AND S. ELHADJ[1,3,5]

[1] *National Ignition Facility and Photon Science, Lawrence Livermore National Laboratory, Livermore, CA 94550, USA*
[2] *Thomas J. Watson Laboratory of Applied Physics, California Institute of Technology, Pasadena, CA 91125, USA*
[3] *Currently at: Seurat Technologies, Inc.,265 Ballardvale St, Wilmington, MA 01887, USA*
[4] *feigenbaum1@llnl.gov*
[5] *selhadj@seuratech.com*

Supplement DOI: https://doi.org/10.6084/m9.figshare.14034935

Parent Article DOI: https://doi.org/10.1364/OE.413843

Toward high laser power beam manipulation with nanophotonic materials: evaluating thin film damage performance: supplemental document

T. U. TUMKUR[1], R. SOKHOYAN[2], M. P. SU[2], A. CEBALLOS-SANCHEZ[1], G. KAFAIE SHIRMANESH [2], Y. KIM[2], H. A. ATWATER[2], E. FEIGENBAUM*[1] S. ELHADJ*[1]

[1] National Ignition Facility and Photon Science, Lawrence Livermore National Laboratory, Livermore CA 94550
[2] Thomas J. Watson Laboratory of Applied Physics, California Institute of Technology, Pasadena, California 91125
*elhadj2@llnl.gov; feigenbaum1@llnl.gov

Table S1: The thin film sample thicknesses and the fitting parameters used for Drude-Lorentz fitting.

Sample	Thickness (nm)	N_e (cm^{-3})	E_p (eV)	Γ_D (eV)	f_1	E_{01} (eV)	γ_1 (eV)	f_2	E_{02} (eV)	γ_2 (eV)	f_3	E_{03} (eV)	γ_3 (eV)	ε_∞	MSE
Au	50	5.92×10^{22}	9.02	0.05	5.55	2.87	0.23	3.41	2.66	0.45	-	-	-	0.96	4.61
ITO	40	4.34×10^{20}	1.31	0.14	1.35	4.11	0.83	27.20	4.81	0.11	-	-	-	3.20	8.20
TiN (metallic)	70	4.74×10^{22}	7.70	0.83	0.75	3.59	0.76	9.15	6.32	3.71	-	-	-	1.47	5.65
TiNxOy (15:45)	65	1.39×10^{22}	4.08	1.52	1.17	1.90	1.41	0.42	4.28	0.45	3.00	3.61	2.91	-	3.26
TiN_xO_y (10:53)	68	9.37×10^{21}	3.42	1.76	2.54	1.68	3.92	0.55	4.86	1.37	2.37	2.59	3.84	0.37	4.00

Table S2: The electrical properties of the Au and ITO samples extracted using Hall effect measurements.

Sample	N_e (cm^{-3})	μ (cm^2/Vs)	Resistivity (μΩcm)
Au	1.6×10^{23}	15.40	2.5
ITO	4.76×10^{20}	16.50	797

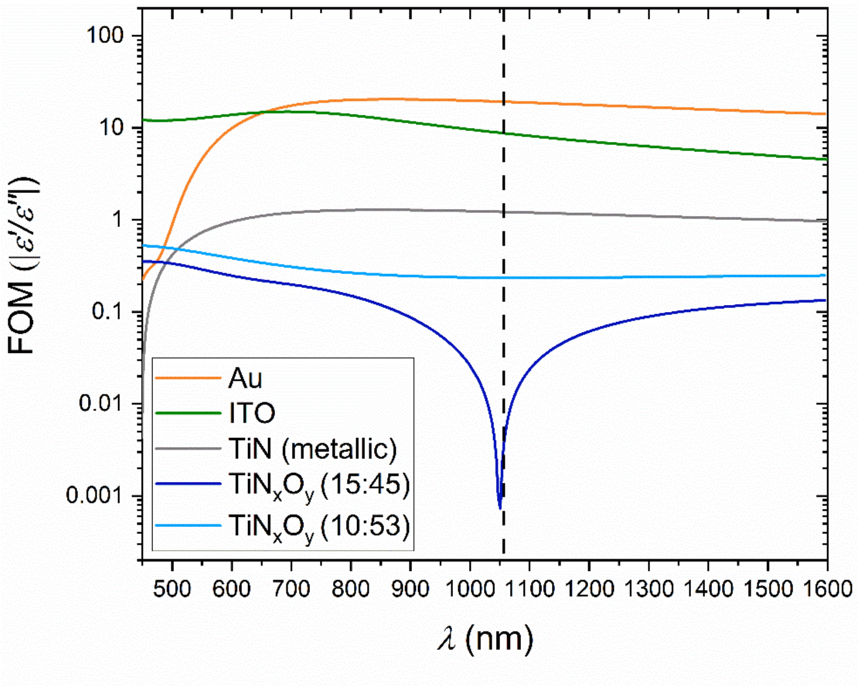

Figure S1: Optical figures of merit (FOM) of the thin films considered in this work.

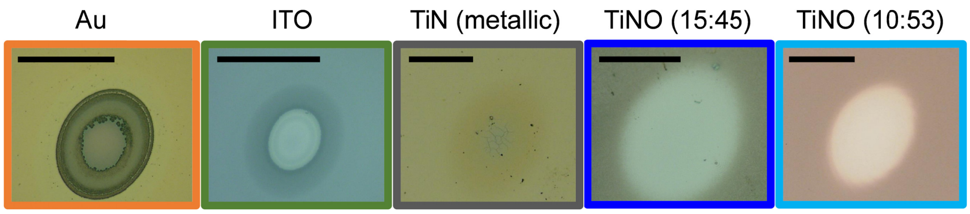

Figure S2: Confocal microscopy images of the damaged spots created by a single-shot laser, with the incident fluences higher than, but close to the laser damage threshold fluence. The samples are identified and color-coded corresponding to respective films indicated in Figure 2. Note that the TiN (metallic) film shown here is slightly thicker than its counterpart shown in Figure 2, (thickness = 120 nm), and is only shown here for completeness. Scale bars are 50 µm.

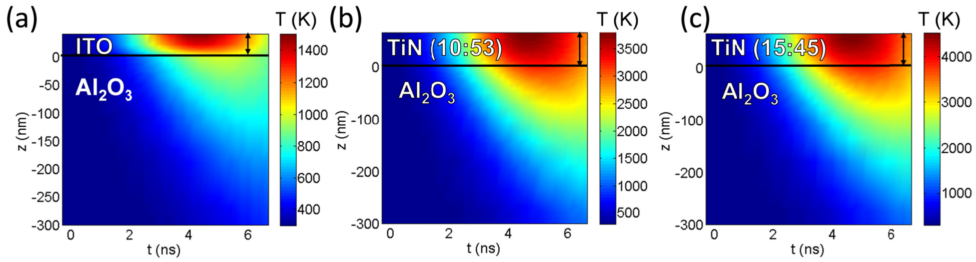

Figure S3: Calculated temperature distributions (following illumination by a single pulse with wavelength = 1064 nm and pulse FWHM = 3.6 ns) as a function of time and axial (z) co-ordinate for (a) 40 nm ITO film, (b) 65 nm TiN_xO_y (10:53) film and (c) 65 nm TiN_xO_y (15:45) film. The substrate in each case is 446 µm thick sapphire. The peak fluence corresponding to each case was equal to from experimentally evaluated threshold fluences, as described in the main text.

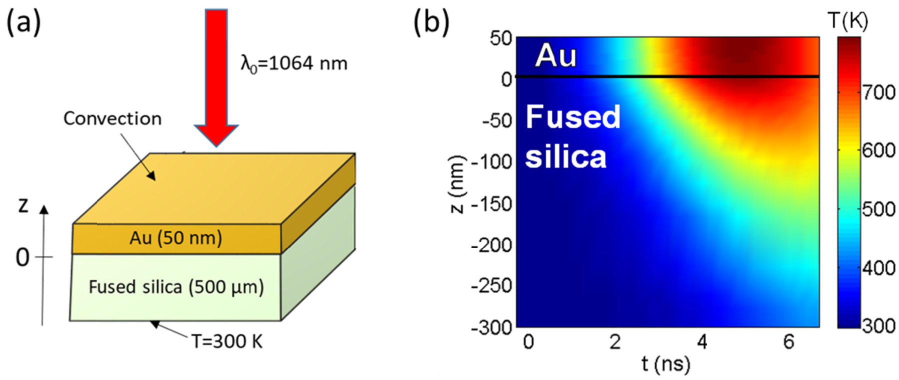

Figure S4: (a) Schematic of a 50 nm-thick Au film on a 500 µm-thick fused silica substrate. The Au film is illuminated by a laser pulse shown in Fig. 4a. (b) Calculated temperature in the structure shown in (a) as a function of the z-coordinate and time. The input peak fluence was set equal to the damage threshold fluence F_{th} = 0.7 J/cm^2 measured experimentally.